DEVELOPMENT OF HIGH TEMPERATURE FACILITY FOR FILTER CHARACTERIZATION DURING FILTER REGENERATION

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Introduction

The development of advanced cycles for more efficient electric power generation requires an effective gas cleaning system upstream of gas turbines. In particular, the gas cleaning system must remove particles from the gas stream at high temperatures. At present, the barrier type filter appears to have the greatest potential for solving this problem. Hundreds of candle (barrier) filters are employed in a chamber to filter out the fine particles from a high temperature stream. As the ash collects on the filter surface, the thickness of the ash deposit increases and generates a relatively large pressure-drop. When the pressure drop exceeds a prescribed value, a pulse of high-pressure gas is injected into the candle filter with the goal of "blowing off" the ash deposits. This surface cleaning process is referred to as surface regeneration.

At present, the surface regeneration process has not been as effective as desired. Deposits remain on the surface after regeneration and they continue to grow in thickness. Eventually, the deposits bridge the gap between adjacent candle filters. This situation is then believed to contribute to candle filter failures; and subsequently, unscheduled plant shut downs. In order to remedy this situation, a more thorough understanding of the deposits' strength characteristics and the surface regeneration process are required.

Objective

The objective of this research effort is to develop a high temperature facility for the measurement of ash deposit characteristics during the regeneration of a candle filter surface. This system will be able to measure the tensile and shear failure strain of the deposit just before the surface regeneration process begins. During this process, the motion and the size distribution of the particles ejected from the surface will be measured. This high temperature facility is to obtain preliminary data for the 80^0F, 500^0F, 1000^0F, and 1500^0F levels. The preliminary design of the high temperature facility is shown in Figure 1.

Approach

In order to satisfy the objective of this research, several tasks have been established. These tasks are:

1. Build a simple model of the high temperature facility to investigate the particle flow characteristics and to act as an aid in developing the optical system. The ability to form an ash deposit on the filter surface and then regenerate the surface in a repeatable manner was to be established. Also, the optical system was to be evaluated using the rather simple structure of the model.

2. Integrate the hardware and software of the optical system for the desired results. Although the hardware and software were commercially available, suitable control logic needed to be developed for the integration of the various components.

3. Construct a simple calibration rig to develop a relationship between the wavelength of the scattered polarized white light and the particle size. This task was necessary in order to determine the size distribution of the ejected particles during surface regeneration.

4. Design and construct the high temperature facility

5. Obtain preliminary data on the ash deposit characteristics at the specified temperatures.

The initial uncertainties in this project were the ability to produce an ash deposit on the candle filter using weathered ash and to develop an optical system with sufficient response to capture the motion and the size distribution of the particles ejected from the surface during regeneration. Both problems appear to be resolved at this time.

Results

The results of the work on this project to date are as follows:

A model of the high temperature facility has been completed and is shown in Figure 2. Tests have shown that the fine powder ash from the ash storage bin may be transported to the filter surface to form an ash deposit. The filter surface may then be regenerated with a pulse of high-pressure gas. The ash used in these tests was from the ash hopper at the Tide Plant in Ohio. The optical system has yet to be installed on the model for its final modifications.

The components of the optical system were integrated and the control logic was developed for the computer. The optical system is shown in Figure 3 and consists of a Pentium 133 computer, a high resolution CCD (1024 x 1024 square pixel) camera, a high speed frame grabber, a variable liquid crystal wavelength filter, and a long distance microscope. This optical system is capable of capturing images at the rate of 30 frames/second.

A calibration rig has been constructed to measure the wavelength of polarized white light scattered, at 90^0F, as a function of particle size. A polarized white light is directed towards a particle of known size and the wavelength of the scattered light is passed through the variable liquid crystal wavelength filter as it goes through its sequence of wavelength filtering. Preliminary results are shown in Figure 4.

Based on the preliminary efforts, a first design for the high temperature facility has been developed and is now under construction. This system is shown in Figure 1. The system is designed for a steady state operation at a maximum temperature of 1500^0F. The face velocity of the "dirty" gas may range from 1 1/4 to 4 inches/second. The last task in this project cannot start until the high temperature facility has been constructed and the optical system installed.

Application

The successful conclusion of this research project will result in an experimental system for the measurement of ash characteristics for various combinations of coal, sorbents, and additives. This database will greatly aid in the development of barrier filter technology. These filters have the advantage over other types of filters in that there is no inherent leakage and there are no moving components in a high temperature environment.

Future Activities

The future activities for this project involve finishing the construction of the high temperature facility and installing the optical system. A set of preliminary tests will then be conducted and a final report written. This will then complete the present research effort. Potential future projects employing the high temperature facility include: 1) determination of the ash deposit characteristics for various combinations of coal ash, sorbents, and additives, 2) attaching the high temperature facility to an atmospheric coal combustor or gasifier, and 3) developing a high- pressure high-temperature facility for the study of ash deposit characteristics.

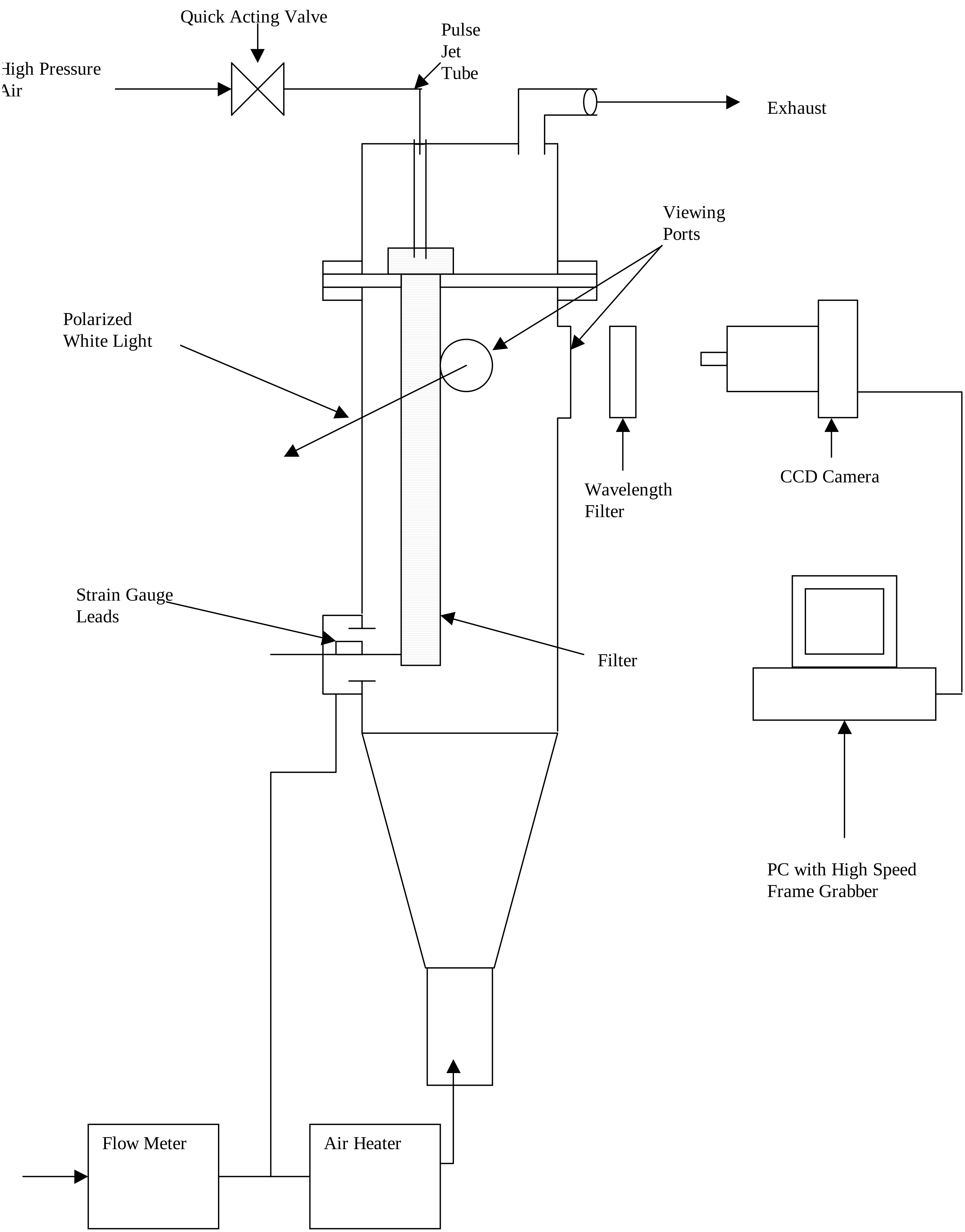

Figure 1. Cross Section of High Temperature Facility

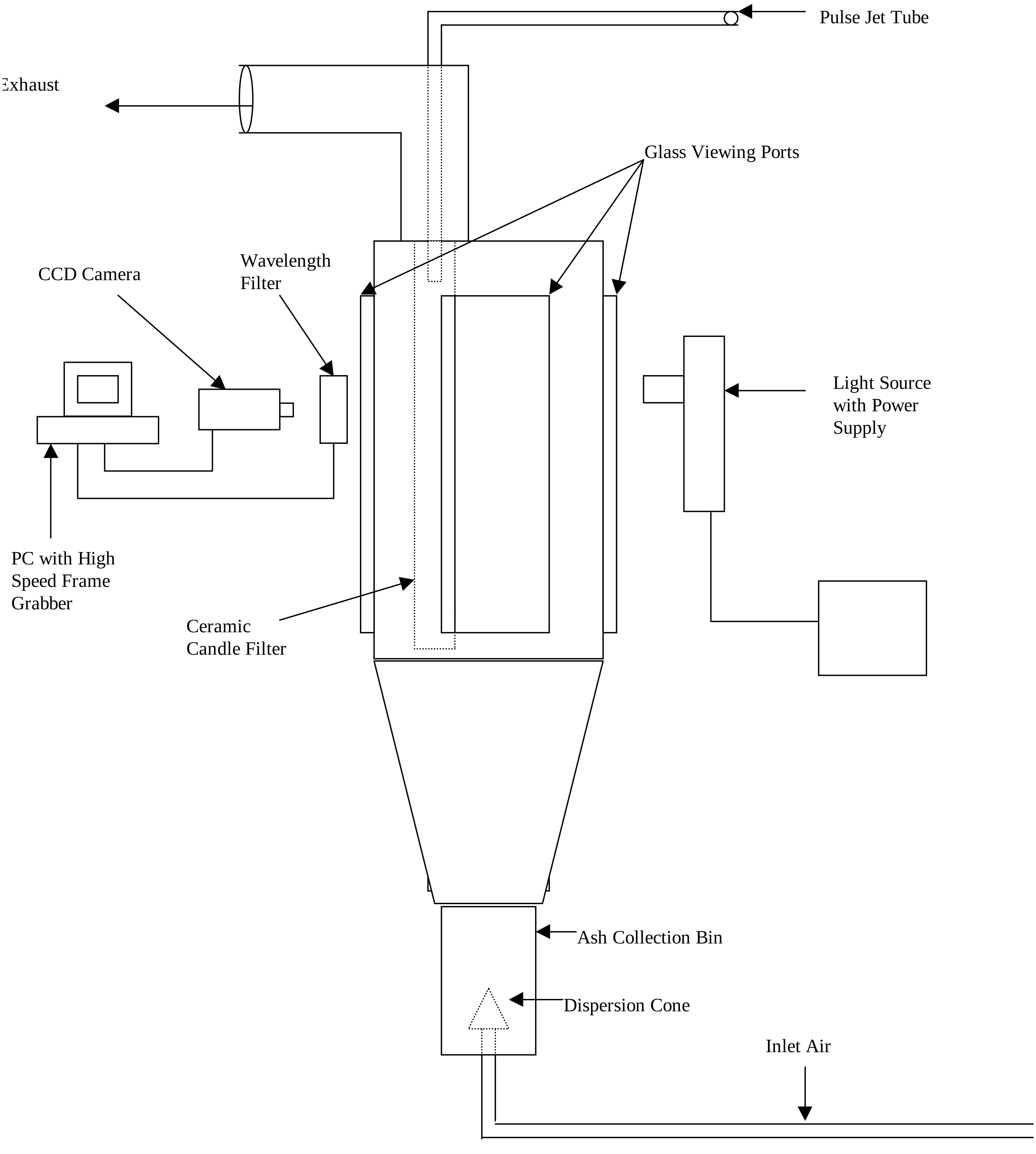

Figure 2. Cross Section of Room Temperature Chamber Model

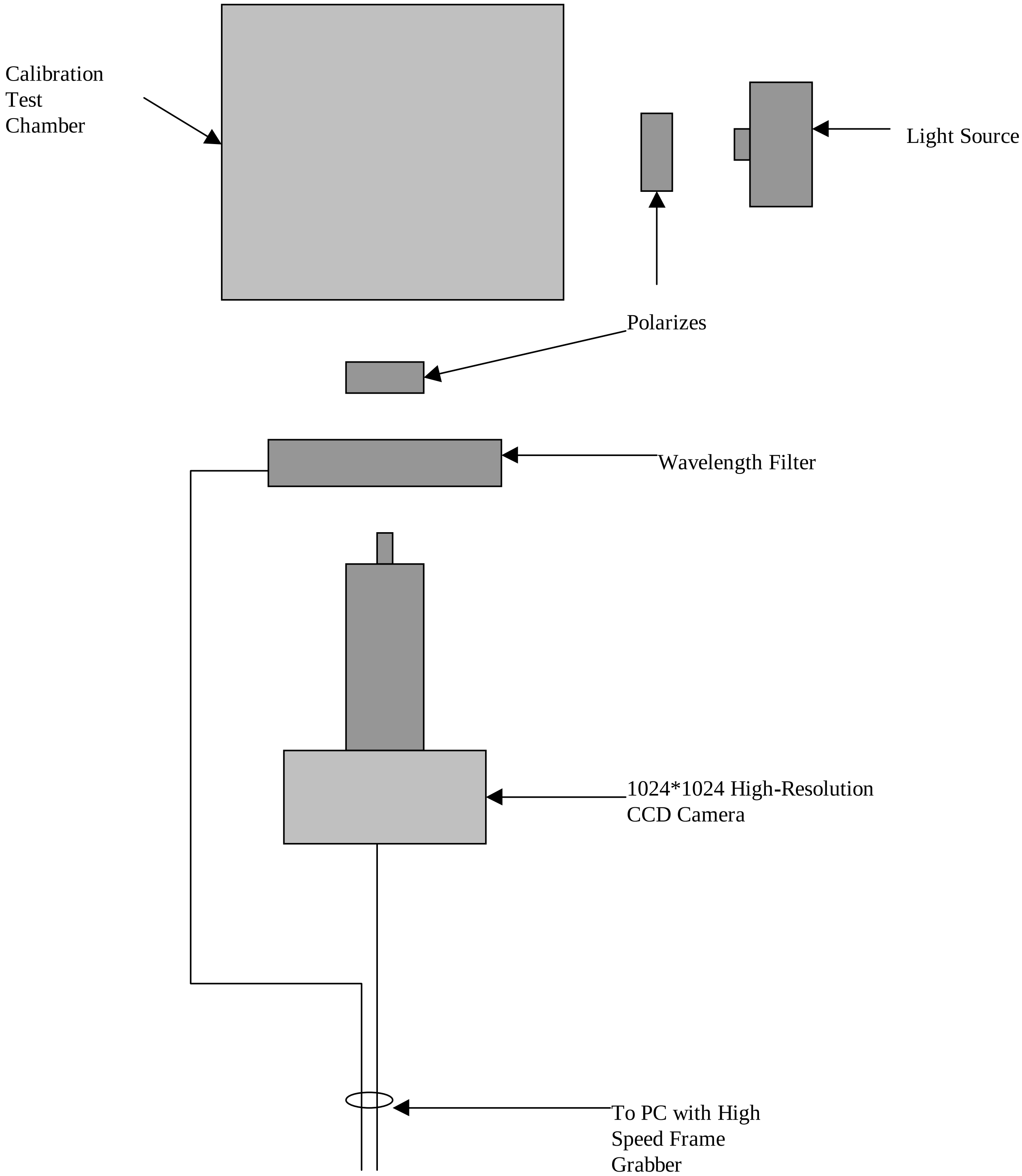

Figure 3. Particle Size Calibration Test Rig

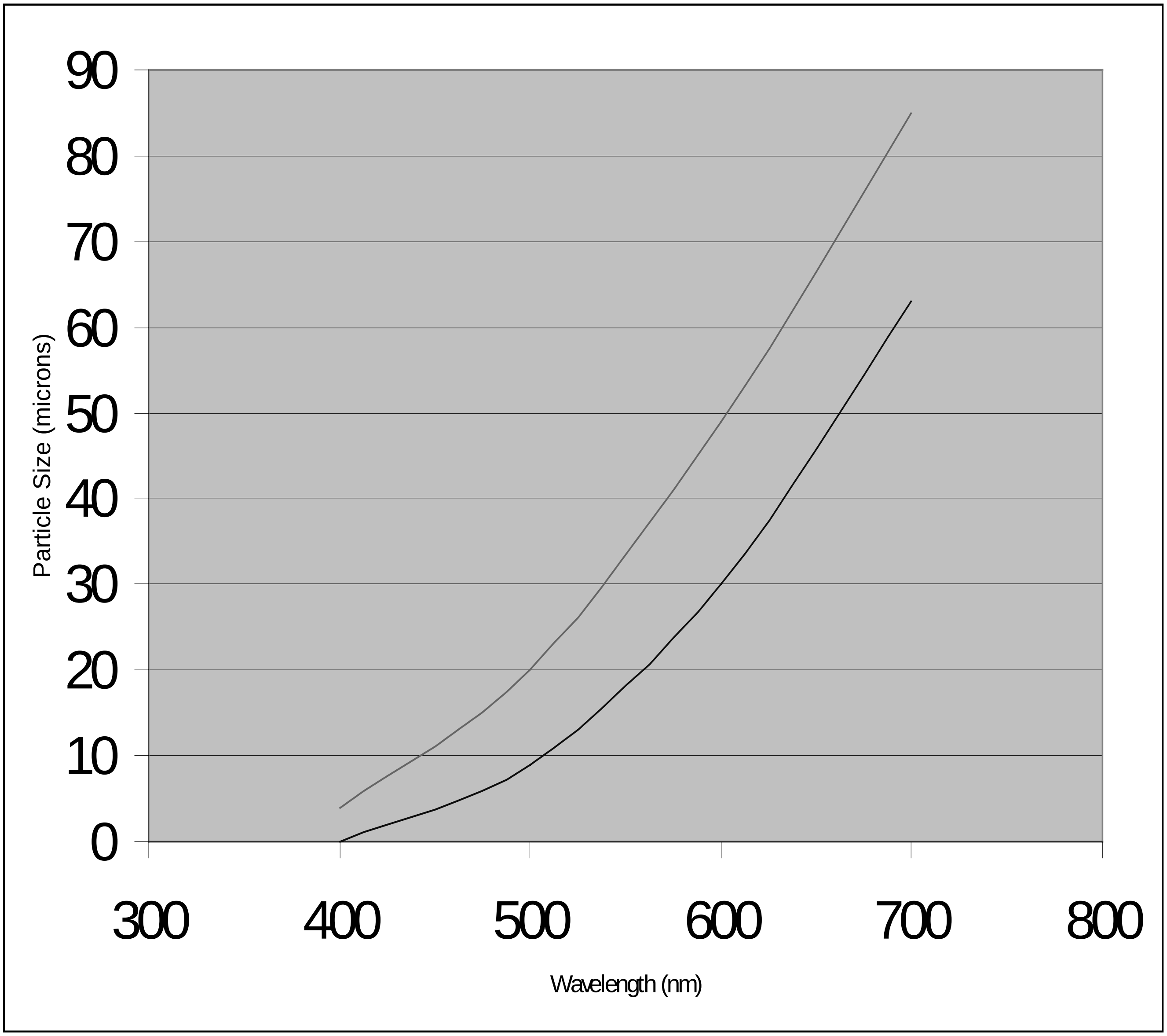

Figure 4. Preliminary Calibration Curve